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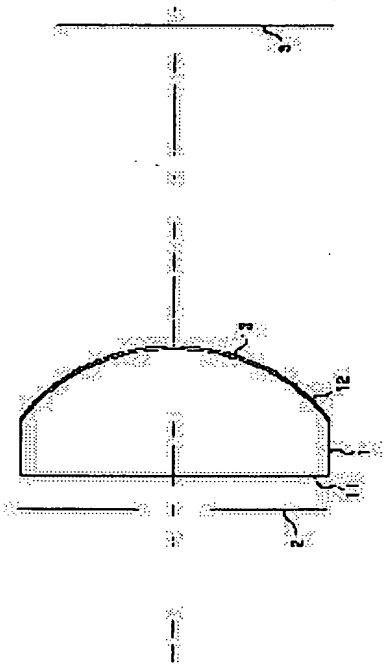
(54) PHOTOGRAPHING OPTICAL SYSTEM AND PHOTOGRAPHING DEVICE

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a photographing optical system with which a sensitivity characteristics or the like of a solid-state imaging element are compensated and an excellent image quality is available with a simple structure.
SOLUTION: The photographing optical system is provided with an aperture diaphragm 2, an interference type optical filter (for example, an infrared cut filter) 13 formed in the form of a curved plane of which center of radius is nearly located at the center of the aperture of the aperture diaphragm. The optical filter can be formed on the surface of a lens 1.



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CLAIMS

[Claim(s)]

[Claim 1] Photography optical system characterized by having a diaphragm and the light filter formed in the shape of [which makes the opening core of this drawing center of curvature mostly] a curved surface.

[Claim 2] Photography optical system according to claim 1 characterized by said light filter being an interference pattern filter.

[Claim 3] Photography optical system according to claim 1 or 2 characterized by having the curved-surface configuration to which said light filter is arranged at an image surface side, and serves as a convex from said drawing at an image surface side.

[Claim 4] Photography optical system according to claim 1 or 2 characterized by having the curved-surface configuration to which said light filter is arranged at a body side, and serves as a convex from said drawing at a body side.

[Claim 5] Photography optical system given in either of claims 1-4 to which said light filter is characterized by being formed on the front face of a lens.

[Claim 6] Photography optical system according to claim 5 to which said light filter is characterized by carrying out vacuum evaporationo formation on the front face of a lens.

[Claim 7] Photography optical system given in either of claims 1-6 characterized by having the solid state image sensor which picturizes the image formed of the flux of light which passed said light filter.

[Claim 8] Photography optical system given in either of claims 1-7 to which said light filter is characterized by being an infrared cut-off filter.

[Claim 9] Photography optical system given in either of claims 1-8 characterized by satisfying $0.7<r/L<1.5$ when the radius of curvature of said light filter is set to r and the direction distance of an optical axis of said diaphragm and said light filter is set to L.

[Claim 10] Photography equipment characterized by equipping either of claims 1-9 with the photography optical system of a publication.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the photography optical system equipped with the light filter for amending especially the sensibility property of a solid state image sensor about the photography optical system used for photography equipments, such as a digital still camera and a video camera.

[0002]

[Description of the Prior Art] When using a solid state image sensor as an image incorporation means in image pick-up equipment, the light filter for amending the spectral sensitivity characteristic is prepared in photography optical system on the property of a solid state image sensor in many cases.

[0003] For example, in order to cut an infrared component, the infrared cut-off filter member of the interference pattern which vapor-deposited dielectric multilayers to the glass substrate just before the solid state image sensor is arranged.

[0004] By the way, in the case of the interference pattern filter using interference of the light by the thin film, the property changes with the incident angles of a beam of light. For example, although it is a setup which reflects light with a wavelength of about 700nm or more in order to usually make the sensibility of a solid state image sensor in agreement with human being's visibility in the case of the infrared cut-off filter of an interference pattern, the wavelength which will reflect this to the incident angle of the set-up light if incident angles differ differs.

[0005] And with the configuration of a common taking lens, the incident angle to a solid state image sensor changes with photographic subject image quantities. Therefore, in such a case, the properties of a light filter will differ.

[0006] In order to avoid this, the so-called telecentric system which arranges a diaphragm in the lens focal location by the side of the image surface rather than a diaphragm is constituted, and it is set up so that the flux of light to all image quantities may carry out incidence to the filter prepared just before the image sensor perpendicularly, so that a lens exit pupil may become infinite distance conventionally.

[0007]

[Problem(s) to be Solved by the Invention] If the miniaturization of an image pick-up lens progresses with the demand of miniaturization of photography equipment, it becomes impossible however, to constitute such telecentric system. Therefore, in having prepared the light filter like before just before the solid state image sensor, unevenness will arise in the sensitivity profile by image quantity.

[0008] Moreover, there is a problem that the flux of light reflected in the filter section becomes the ghost who reflects at other peripheries and lens barrel edges of a lens, takes a complicated optical path, and cannot shade, or serves as ghost light which the reflected light of the front face of a solid state image sensor reflects with a light filter, and carries out incidence to a solid state image sensor again when the light filter of an interference pattern is formed in some image pick-up lenses which consist of two or more lenses.

[0009] Then, this invention is a simple configuration, can amend the sensibility property of a solid state image sensor etc., and aims at offering the photography optical system which can acquire good image quality.

[0010]

[Means for Solving the Problem] in order to attain the above-mentioned purpose, the photography optical system of this invention has a diaphragm and the light filter (for example, infrared cut-off filter of an interference pattern) formed in the shape of [which makes the opening core of this drawing center of curvature mostly (getting it blocked -- the core of diaphragm opening -- receiving -- almost -- KONN -- a trick)] a curved surface.

[0011] A light filter is formed in the curved-surface configuration which is on a body side with a convex, when a light filter is formed in the curved-surface configuration which is on an image surface side with a convex when a light filter extracts and the twist is also specifically arranged at the image surface side, or a light filter extracts and the twist is also arranged at the body side.

[0012] Even if optical system is not constituted as telecentric system by this, it becomes possible not to depend whenever [incident angle / of the beam of light to a light filter] on image quantity, but to make it almost the same, a dependency is reduced whenever [incident angle / of the light filter of an interference pattern], and it becomes possible to acquire good photography image quality.

[0013] Moreover, since the light filter is formed in the above-mentioned configuration in case the beam of light which reached the image surface reflects in a light filter side on front faces, such as a solid state image sensor arranged in the image surface, and reflects with a light filter further, emission or astriction will be received, in case this reflected ray carries out incidence to an image sensor again, the flux of light has spread, and the effect on the image pick-up engine performance decreases.

[0014] It is $0.7<r/L<1.5$, when the radius of curvature of a light filter is set to r and the direction distance of an optical axis of a diaphragm and a light filter is especially set to L. -- (1)

Constituting so that it may be satisfied is desirable.

[0015] If it deviates from the range of the above-mentioned formula (1), the filter shape by whenever [incident angle] will change a lot, and the image from which image quality and the quantity of light differ by image quantity will be formed. Moreover, possibility of being influenced of the ghost by the reflected light in a filter becomes high.

[0016] In addition, by forming a light filter on the front face of lenses (image formation lens etc.) required for optical system originally, the light filter member which the former became independent of is made unnecessary, and it becomes possible to acquire the above-mentioned effectiveness, preventing the increment in the number of components.

[0017]

[Embodiment of the Invention] (The 1st operation gestalt) The configuration of the photography optical system which is the 1st operation gestalt of this invention is shown in drawing 1 . In addition, this photography optical system is used for photography equipments, such as a digital still camera and a video camera, is held in the lens barrel constituted in one by the body of photography equipment, or is held in a removable interchangeable lens to the body of photography equipment.

[0018] In drawing 1 , 2 is a diaphragm and opening for passing the photography flux of light is formed in the center.

[0019] 1 is an image formation lens and is arranged rather than the diaphragm 2 at the image surface side. The field by the side of the body of this image formation lens 1 is constituted as a flat surface 11, and the field by the side of the image surface is constituted as a convex 12. 3 is an image formation side and solid state image sensors, such as CCD, are arranged here.

[0020] On the convex 12 of the image formation lens 1, the infrared cut-off filter (interference pattern light filter) 13 by dielectric multilayers is formed of vacuum evaporationo. This infrared cut-off filter 13 has the property of reflecting the great portion of light with a wavelength of about 700nm or more, and has the work which doubles the wavelength sensitivity profile of a solid state image sensor with visibility.

[0021] And the center of curvature of the convex 12 of the image formation lens 1 is set up so that it may be mostly in agreement with the opening core of diaphragm 2. For this reason, the center of curvature of the infrared cut-off filter 13 formed on the convex 12 is also mostly in agreement with the opening core of diaphragm 2.

[0022] Thereby, incidence of the chief ray (the light which carried out incidence aslant not only to the beam of light which carried out incidence in parallel with an optical axis but to the optical axis is included) passing through the opening core of diaphragm 2 is carried out almost

at right angles to a convex 12 and the infrared cut-off filter 13.

[0023] That is, whenever [incident angle / of the beam of light to the infrared cut-off filter 13] is not based on image quantity, but becomes almost the same. Thereby, the difference in the cut wavelength by the degree difference of incident angle to the infrared cut-off filter 13 can be made small, and color temperature change by image quantity and change of the quantity of light can be made small.

[0024] The locus of the infrared-region beam of light reflected by the beam of light of the visible region which passes diaphragm 2, the image formation lens 1, and the infrared cut-off filter 13, and carries out incidence to a solid state image sensor, the locus of the beam of light containing the wavelength of the infrared region which passed the infrared cut-off filter 13 although it was small, and the front face and the infrared cut-off filter 13 (it has a reflection factor high naturally in an infrared region) of a solid state image sensor is shown in drawing 2.

[0025] It reflects by the infrared cut-off filter 13, and the infrared light line reflected with the solid state image sensor goes in the direction of an image sensor again.

[0026] However, with this operation gestalt, when the infrared cut-off filter 13 is on the image surface side with the convex, the infrared light line RL reflected by the infrared cut-off filter 13 receives big transpiration, and in case incidence is again carried out to a solid state image sensor, when the flux of light has spread, the effect on the image pick-up engine performance will become slight.

[0027] On the other hand, the locus of the beam of light reflected at the front face of a solid state image sensor and the flat surface 11 of the image formation lens 1 is shown in drawing 3.

[0028] The beam of light which reflected in respect of [31] the image sensor front face, and carried out incidence to the image formation lens 1 serves as the parallel flux of light mostly in an operation of a convex 12, and is reflected at a flat surface 11. This reflected ray goes in the direction of an image sensor in response to a condensing operation in a convex 12 again. Consequently, the fully condensed light will carry out image formation to the point 32 on the front face of an image sensor, and it will become ghost light with the big effect of the image formation engine performance on original. Therefore, it is not desirable to install the filter which cuts an unnecessary wavelength component by reflection in a flat surface 11. The acid-resisting filter which reduces a reflection factor in the wavelength whole region rather should be installed here.

[0029] Next, the numerical example of this operation gestalt is explained. When

the focal distance of photography optical system is set to 1, Curvature Spacing A refractive index r/L It extracts. (2) infinity 0.1 1 (air) - S1 (flat surface 11) infinity 0.3962 1.5247 infinity S2 (convex 12) -0.52793 1 (air) 1.06 It is related.

[0030] That is, with this operation gestalt, change of the filter shape which is the above-mentioned formula (1) have satisfied $0.7<r/L=1.06<1.5$ and according to whenever [incident angle] was lessened, and it has prevented that image quality and the quantity of light change with image quantities. Moreover, effect of the ghost by the reflected light in a filter 13 is lessened.

[0031] In addition, some modification may be added to a configuration by making S2 (convex 12) into the aspheric surface for a **** engine-performance improvement.

[0032] (The 2nd operation gestalt) The configuration of the photography optical system which is the 2nd operation gestalt of this invention is shown in drawing 4 . In addition, this photography optical system is used for photography equipments, such as a digital still camera and a video camera, is held in the lens barrel constituted in one by the body of photography equipment, or is held in a removable interchangeable lens to the body of photography equipment.

[0033] In drawing 4 , 2 is a diaphragm and opening for passing the photography flux of light is formed in the center.

[0034] 20 is an image formation lens and is arranged rather than the diaphragm 2 at the body side. The field by the side of the body of this image formation lens 20 is constituted as a convex 21, and the field by the side of the image surface is constituted as a concave surface 22. 3 is an image formation side and solid state image sensors, such as CCD, are arranged here.

[0035] On the convex 21 of the image formation lens 20, the infrared cut-off filter (interference pattern light filter) 23 by dielectric multilayers is formed of vacuum evaporationo. This infrared cut-off filter 23 has the property of reflecting light with a wavelength of about 700nm or more, and has the work which doubles the wavelength sensitivity profile of a solid state image sensor with visibility.

[0036] And the center of curvature of the convex 21 of the image formation lens 20 is set up so that it may be mostly in agreement with the opening core of diaphragm 2. For this reason, the center of curvature of the infrared cut-off filter 23 formed on the convex 21 is also mostly in agreement with the opening core of diaphragm 2.

[0037] Thereby, incidence of the chief ray passing through the opening core of diaphragm 2 is carried out almost at right angles to a convex 21 and the infrared cut-off filter 23.

[0038] That is, whenever [incident angle

/ of the beam of light to the infrared cut-off filter 23] is not based on image quantity, but becomes almost the same. Thereby, the difference in the cut wavelength by the degree difference of incident angle to the infrared cut-off filter 23 can be made small, and color temperature change by image quantity and change of the quantity of light can be made small.

[0039] The locus of the beam of light reflected by the beam of light of the visible region which passes the infrared cut-off filter 23, the image formation lens 20, and diaphragm 2, and carries out incidence to a solid state image sensor, the locus of the beam of light containing the wavelength of the infrared region which passed the infrared cut-off filter 21 although it was small, and the front face and the infrared cut-off filter 21 of a solid state image sensor is shown in drawing 5 .

[0040] The concave surface 22 and convex 21 of a lens 20 are penetrated, it reflects by the infrared cut-off filter 23, and the beam of light reflected with the solid state image sensor only carries out going in the direction of an image sensor again. With this operation gestalt When the infrared cut-off filter 23 is on the body side with the convex, the beam of light RL reflected by the infrared cut-off filter 23 receives big astriction, and in case incidence is again carried out to a solid state image sensor, when the flux of light has spread, the effect on the image pick-up engine performance will become slight.

[0041] On the other hand, the locus of the beam of light reflected on the front face of a solid state image sensor and the concave surface 22 of the image formation lens 20 is shown in drawing 6 .

[0042] The beam of light reflected on the image sensor front face goes in the direction of an image sensor in response to a condensing operation by reflection on a concave surface 22. Consequently, to an image sensor front face, the fully condensed light will carry out image formation, and will turn into ghost light with the big effect of the image formation engine performance on original on it. Therefore, it is not desirable to prepare the filter which cuts an unnecessary wavelength component into a concave surface 22 by reflection.

[0043] Next, the numerical example of this operation gestalt is explained. When the focal distance of photography optical system is set to 1, Curvature Spacing A refractive index r/L S1 (convex 21) 0.36829 0.06425 1.5247 1.44 S2 (concave surface 22) 1.14456 0.19202 1 (air) 5.96 It extracts. (2) infinity 1 (air) By -, i.e., this operation gestalt, change of the filter shape which is the above-mentioned formula (1) have satisfied $0.7<r/L=1.44<1.5$ and according to whenever [incident angle] was lessened, and it has prevented that image quality and the quantity of light change with

image quantities. Moreover, effect of the ghost by the reflected light in a filter 23 is lessened.

[0044] In addition, some modification may be added to a configuration by making S1 (convex 21) and S2 (concave surface 22) into the aspheric surface for a **** engine-performance improvement.

[0045] Moreover, although each above-mentioned operation gestalt explained the case where vacuum evaporationo formation of the interference pattern infrared cut-off filter was carried out, on the front face of an image formation lens, light filters other than an infrared cut-off filter may be formed by approaches other than vacuum evaporationo on the front face of an image formation lens, and you may make it form a light filter in this invention on the transparence plate of the curved-surface configuration which makes the opening core of a diaphragm center of curvature mostly.

[0046] Moreover, this invention is a light filter which is not an interference pattern, and also when using what has a dependency in the property whenever [incident angle], it can be applied. For example, since what forms detailed irregularity on a glass substrate, gives the diffusion property of light, uses for the filter of a taking lens etc., and acquires the soft focus effectiveness changes a diffusion property according to the incident angle of light, if it is going to acquire fixed effectiveness, its application of this invention is effective.

[0047]

[Effect of the Invention] Since the opening core of a diaphragm of a light filter is formed in the shape of [which is mostly made into center of curvature] a curved surface according to this invention as explained above, even if optical system is not constituted as telecentric system, whenever [incident angle / of the beam of light to a light filter] cannot be depended on image quantity, but can be made almost the same. Therefore, a dependency can be reduced whenever [incident angle / of the light filter of an interference pattern], and good photography image quality can be acquired.

[0048] Moreover, since the light filter is formed in the above-mentioned configuration and emission or astriction will be received in case the beam of light which reached the image surface reflects in a light filter side on front faces, such as a solid state image sensor arranged in the image surface, and reflects with a light filter further, in case this reflected beam of light carries out incidence to an image sensor again, the flux of light has spread, and effect on the image pick-up engine performance can be lessened.

[0049] If it constitutes so that the above-mentioned formula (1) may be satisfied when the radius of curvature of a light filter is set to r and the direction

distance of an optical axis of a diaphragm and a light filter is especially set to L, change of the filter shape by whenever [incident angle] is lessened, and it can prevent that the image from which image quality and the quantity of light differ by image quantity is formed. Moreover, effect of the ghost by the reflected light in a light filter can be lessened.

[0050] In addition, if a light filter is formed on the front face of lenses (image formation lens etc.) required for optical system originally, the light filter member which the former became independent of is made unnecessary, and the above-mentioned effectiveness can be acquired, preventing the increment in the number of components.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] The block diagram of the photography optical system which is the 1st operation gestalt of this invention.

[Drawing 2] Drawing showing the locus of the beam of light in the above-mentioned photography optical system.

[Drawing 3] Drawing showing the locus of the beam of light in the above-mentioned photography optical system.

[Drawing 4] The block diagram of the photography optical system which is the 2nd operation gestalt of this invention.

[Drawing 5] Drawing showing the locus of the beam of light in the photography optical system of the above-mentioned 2nd operation gestalt.

[Drawing 6] Drawing showing the locus of the beam of light in the photography optical system of the above-mentioned 2nd operation gestalt.

[Description of Notations]

1 20 Image formation lens

2 Drawing

3 Image Formation Side (Installation Side of Individual Image Sensor)

13 23 Infrared cut-off filter

[Translation done.]

CLAIMS

[Claim(s)]

[Claim 1] Photography optical system characterized by having a diaphragm and the light filter formed in the shape of [which makes the opening core of this drawing center of curvature mostly] a curved surface.

[Claim 2] Photography optical system according to claim 1 characterized by said light filter being an interference pattern filter.

[Claim 3] Photography optical system according to claim 1 or 2 characterized by having the curved-surface configuration to which said light filter is arranged at an image surface side, and serves as a convex from said drawing at an image surface side.

[Claim 4] Photography optical system according to claim 1 or 2 characterized by having the curved-surface configuration to which said light filter is arranged at a body side, and serves as a convex from said drawing at a body side.

[Claim 5] Photography optical system given in either of claims 1-4 to which said light filter is characterized by being formed on the front face of a lens.

[Claim 6] Photography optical system according to claim 5 to which said light filter is characterized by carrying out vacuum evaporationo formation on the front face of a lens.

[Claim 7] Photography optical system given in either of claims 1-6 characterized by having the solid state image sensor which picturizes the image formed of the flux of light which passed said light filter.

[Claim 8] Photography optical system given in either of claims 1-7 to which said light filter is characterized by being an infrared cut-off filter.

[Claim 9] Photography optical system given in either of claims 1-8 characterized by satisfying $0.7<r/L<1.5$ when the radius of curvature of said light filter is set to r and the direction distance of an optical axis of said diaphragm and said light filter is set to L.

[Claim 10] Photography equipment characterized by equipping either of claims 1-9 with the photography optical system of a publication.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the photography optical system equipped with the light filter for amending especially the sensibility property of a solid state image sensor about the photography optical system used for photography equipments, such as a digital still camera and a video camera.

[0002]

[Description of the Prior Art] When using a solid state image sensor as an image incorporation means in image pick-up equipment, the light filter for amending the spectral sensitivity characteristic is prepared in photography optical system on the property of a solid state image sensor in many cases.

[0003] For example, in order to cut an infrared component, the infrared cut-off filter member of the interference pattern which vapor-deposited dielectric multilayers to the glass substrate just before the solid state image sensor is arranged.

[0004] By the way, in the case of the interference pattern filter using interference of the light by the thin film, the property changes with the incident angles of a beam of light. For example, although it is a setup which reflects light with a wavelength of about 700nm or more in order to usually make the sensibility of a solid state image sensor in agreement with human being's visibility in the case of the infrared cut-off filter of an interference pattern, the wavelength which will reflect this to the incident angle of the set-up light if incident angles differ differs.

[0005] And with the configuration of a common taking lens, the incident angle to a solid state image sensor changes with photographic subject image quantities. Therefore, in such a case, the properties of a light filter will differ.

[0006] In order to avoid this, the so-called telecentric system which arranges a diaphragm in the lens focal location by the side of the image surface rather than a diaphragm is constituted, and it is set up so that the flux of light to all image quantities may carry out incidence to the filter prepared just before the image sensor perpendicularly, so that a lens exit pupil may become infinite distance conventionally.

[0007]

[Problem(s) to be Solved by the Invention] If the miniaturization of an image pick-up lens progresses with the demand of miniaturization of photography equipment, it becomes impossible however, to constitute such telecentric system. Therefore, in having prepared the light filter like before just before the solid state image sensor, unevenness will arise in the sensitivity profile by image quantity.

[0008] Moreover, there is a problem that the flux of light reflected in the filter section becomes the ghost who reflects at other peripheries and lens barrel edges of a lens, takes a complicated optical path, and cannot shade, or serves as ghost light which the reflected light of the front face of a solid state image sensor reflects with a light filter, and carries out incidence to a solid state image sensor again when the light filter of an interference pattern is formed in some image pick-up lenses which consist of two or more lenses.

[0009] Then, this invention is a simple configuration, can amend the sensibility property of a solid state image sensor etc., and aims at offering the photography optical system which can acquire good image quality.

[0010]

[Means for Solving the Problem] in order to attain the above-mentioned purpose, the photography optical system of this invention has a diaphragm and the light filter (for example, infrared cut-off filter of an interference pattern) formed in the shape of [which makes the opening core of this drawing center of curvature mostly (getting it blocked -- the core of diaphragm opening -- receiving -- almost -- KONN -- a trick)] a curved surface.

[0011] A light filter is formed in the curved-surface configuration which is on a body side with a convex, when a light filter is formed in the curved-surface configuration which is on an image surface side with a convex when a light filter extracts and the twist is also specifically arranged at the image surface side, or a light filter extracts and the twist is also arranged at the body side.

[0012] Even if optical system is not constituted as telecentric system by this, it becomes possible not to depend whenever [incident angle / of the beam of light to a light filter] on image quantity, but to make it almost the same, a dependency is reduced whenever [incident angle / of the light filter of an interference pattern], and it becomes possible to acquire good photography image quality.

[0013] Moreover, since the light filter is formed in the above-mentioned configuration in case the beam of light which reached the image surface reflects in a light filter side on front faces, such as a solid state image sensor arranged in the image surface, and reflects with a light filter further, emission or astriction will be received, in case this reflected ray carries out incidence to an image sensor again, the flux of light has spread, and the effect on the image pick-up engine performance decreases.

[0014] It is $0.7<r/L<1.5$, when the radius of curvature of a light filter is set to r and the direction distance of an optical axis of a diaphragm and a light filter is especially set to L. -- (1)

Constituting so that it may be satisfied is desirable.

[0015] If it deviates from the range of the above-mentioned formula (1), the filter shape by whenever [incident angle] will change a lot, and the image from which image quality and the quantity of light differ by image quantity will be formed. Moreover, possibility of being influenced of the ghost by the reflected light in a filter becomes high.

[0016] In addition, by forming a light filter on the front face of lenses (image formation lens etc.) required for optical system originally, the light filter member which the former became independent of is made unnecessary, and it becomes possible to acquire the above-mentioned effectiveness, preventing the increment in the number of components.

[0017]

[Embodiment of the Invention] (The 1st operation gestalt) The configuration of the photography optical system which is the 1st operation gestalt of this invention is shown in drawing 1 . In addition, this photography optical system is used for photography equipments, such as a digital still camera and a video camera, is held in the lens barrel constituted in one by the body of photography equipment, or is held in a removable interchangeable lens to the body of photography equipment.

[0018] In drawing 1 , 2 is a diaphragm and opening for passing the photography flux of light is formed in the center.

[0019] 1 is an image formation lens and is arranged rather than the diaphragm 2 at the image surface side. The field by the side of the body of this image formation lens 1 is constituted as a flat surface 11, and the field by the side of the image surface is constituted as a convex 12. 3 is an image formation side and solid state image sensors, such as CCD, are arranged here.

[0020] On the convex 12 of the image formation lens 1, the infrared cut-off filter (interference pattern light filter) 13 by dielectric multilayers is formed of vacuum evaporationo. This infrared cut-off filter 13 has the property of reflecting the great portion of light with a wavelength of about 700nm or more, and has the work which doubles the wavelength sensitivity profile of a solid state image sensor with visibility.

[0021] And the center of curvature of the convex 12 of the image formation lens 1 is set up so that it may be mostly in agreement with the opening core of diaphragm 2. For this reason, the center of curvature of the infrared cut-off filter 13 formed on the convex 12 is also mostly in agreement with the opening core of diaphragm 2.

[0022] Thereby, incidence of the chief ray (the light which carried out incidence aslant not only to the beam of light which carried out incidence in parallel with an optical axis but to the optical axis is included) passing through the opening core of diaphragm 2 is carried out almost

at right angles to a convex 12 and the infrared cut-off filter 13.

[0023] That is, whenever [incident angle / of the beam of light to the infrared cut-off filter 13] is not based on image quantity, but becomes almost the same. Thereby, the difference in the cut wavelength by the degree difference of incident angle to the infrared cut-off filter 13 can be made small, and color temperature change by image quantity and change of the quantity of light can be made small.

[0024] The locus of the infrared-region beam of light reflected by the beam of light of the visible region which passes diaphragm 2, the image formation lens 1, and the infrared cut-off filter 13, and carries out incidence to a solid state image sensor, the locus of the beam of light containing the wavelength of the infrared region which passed the infrared cut-off filter 13 although it was small, and the front face and the infrared cut-off filter 13 (it has a reflection factor high naturally in an infrared region) of a solid state image sensor is shown in drawing 2 .

[0025] It reflects by the infrared cut-off filter 13, and the infrared light line reflected with the solid state image sensor goes in the direction of an image sensor again.

[0026] However, with this operation gestalt, when the infrared cut-off filter 13 is on the image surface side with the convex, the infrared light line RL reflected by the infrared cut-off filter 13 receives big transpiration, and in case incidence is again carried out to a solid state image sensor, when the flux of light has spread, the effect on the image pick-up engine performance will become slight.

[0027] On the other hand, the locus of the beam of light reflected at the front face of a solid state image sensor and the flat surface 11 of the image formation lens 1 is shown in drawing 3 .

[0028] The beam of light which reflected in respect of [31] the image sensor front face, and carried out incidence to the image formation lens 1 serves as the parallel flux of light mostly in an operation of a convex 12, and is reflected at a flat surface 11. This reflected ray goes in the direction of an image sensor in response to a condensing operation in a convex 12 again. Consequently, the fully condensed light will carry out image formation to the point 32 on the front face of an image sensor, and it will become ghost light with the big effect of the image formation engine performance on original. Therefore, it is not desirable to install the filter which cuts an unnecessary wavelength component by reflection in a flat surface 11. The acid-resisting filter which reduces a reflection factor in the wavelength whole region rather should be installed here.

[0029] Next, the numerical example of this operation gestalt is explained. When

the focal distance of photography optical system is set to 1, Curvature Spacing A refractive index r/L It extracts. (2) infinity 0.1 1 (air) - S1 (flat surface 11) infinity 0.3962 1.5247 infinity S2 (convex 12) -0.52793 1 (air) 1.06 It is related.

[0030] That is, with this operation gestalt, change of the filter shape which is the above-mentioned formula (1) have satisfied 0.7<r/L=1.06<1.5 and according to whenever [incident angle] was lessened, and it has prevented that image quality and the quantity of light change with image quantities. Moreover, effect of the ghost by the reflected light in a filter 13 is lessened.

[0031] In addition, some modification may be added to a configuration by making S2 (convex 12) into the aspheric surface for a **** engine-performance improvement.

[0032] (The 2nd operation gestalt) The configuration of the photography optical system which is the 2nd operation gestalt of this invention is shown in drawing 4 . In addition, this photography optical system is used for photography equipments, such as a digital still camera and a video camera, is held in the lens barrel constituted in one by the body of photography equipment, or is held in a removable interchangeable lens to the body of photography equipment.

[0033] In drawing 4 , 2 is a diaphragm and opening for passing the photography flux of light is formed in the center.

[0034] 20 is an image formation lens and is arranged rather than the diaphragm 2 at the body side. The field by the side of the body of this image formation lens 20 is constituted as a convex 21, and the field by the side of the image surface is constituted as a concave surface 22. 3 is an image formation side and solid state image sensors, such as CCD, are arranged here.

[0035] On the convex 21 of the image formation lens 20, the infrared cut-off filter (interference pattern light filter) 23 by dielectric multilayers is formed of vacuum evaporationo. This infrared cut-off filter 23 has the property of reflecting light with a wavelength of about 700nm or more, and has the work which doubles the wavelength sensitivity profile of a solid state image sensor with visibility.

[0036] And the center of curvature of the convex 21 of the image formation lens 20 is set up so that it may be mostly in agreement with the opening core of diaphragm 2. For this reason, the center of curvature of the infrared cut-off filter 23 formed on the convex 21 is also mostly in agreement with the opening core of diaphragm 2.

[0037] Thereby, incidence of the chief ray passing through the opening core of diaphragm 2 is carried out almost at right angles to a convex 21 and the infrared cut-off filter 23.

[0038] That is, whenever [incident angle

/ of the beam of light to the infrared cut-off filter 23] is not based on image quantity, but becomes almost the same. Thereby, the difference in the cut wavelength by the degree difference of incident angle to the infrared cut-off filter 23 can be made small, and color temperature change by image quantity and change of the quantity of light can be made small.

[0039] The locus of the beam of light reflected by the beam of light of the visible region which passes the infrared cut-off filter 23, the image formation lens 20, and diaphragm 2, and carries out incidence to a solid state image sensor, the locus of the beam of light containing the wavelength of the infrared region which passed the infrared cut-off filter 21 although it was small, and the front face and the infrared cut-off filter 21 of a solid state image sensor is shown in drawing 5 .

[0040] The concave surface 22 and convex 21 of a lens 20 are penetrated, it reflects by the infrared cut-off filter 23, and the beam of light reflected with the solid state image sensor only carries out going in the direction of an image sensor again. With this operation gestalt When the infrared cut-off filter 23 is on the body side with the convex, the beam of light RL reflected by the infrared cut-off filter 23 receives big astriction, and in case incidence is again carried out to a solid state image sensor, when the flux of light has spread, the effect on the image pick-up engine performance will become slight.

[0041] On the other hand, the locus of the beam of light reflected on the front face of a solid state image sensor and the concave surface 22 of the image formation lens 20 is shown in drawing 6 .

[0042] The beam of light reflected on the image sensor front face goes in the direction of an image sensor in response to a condensing operation by reflection on a concave surface 22. Consequently, to an image sensor front face, the fully condensed light will carry out image formation, and will turn into ghost light with the big effect of the image formation engine performance on original on it. Therefore, it is not desirable to prepare the filter which cuts an unnecessary wavelength component into a concave surface 22 by reflection.

[0043] Next, the numerical example of this operation gestalt is explained. When the focal distance of photography optical system is set to 1, Curvature Spacing A refractive index r/L S1 (convex 21) 0.36829 0.06425 1.5247 1.44 S2 (concave surface 22) 1.14456 0.19202 1 (air) 5.96 It extracts. (2) infinity 1 (air) By -, i.e., this operation gestalt, change of the filter shape which is the above-mentioned formula (1) have satisfied $0.7<r/L=1.44<1.5$ and according to whenever [incident angle] was lessened, and it has prevented that image quality and the quantity of light change with

image quantities. Moreover, effect of the ghost by the reflected light in a filter 23 is lessened.

[0044] In addition, some modification may be added to a configuration by making S1 (convex 21) and S2 (concave surface 22) into the aspheric surface for a **** engine-performance improvement.

[0045] Moreover, although each above-mentioned operation gestalt explained the case where vacuum evaporationo formation of the interference pattern infrared cut-off filter was carried out, on the front face of an image formation lens, light filters other than an infrared cut-off filter may be formed by approaches other than vacuum evaporationo on the front face of an image formation lens, and you may make it form a light filter in this invention on the transparence plate of the curved-surface configuration which makes the opening core of a diaphragm center of curvature mostly.

[0046] Moreover, this invention is a light filter which is not an interference pattern, and also when using what has a dependency in the property whenever [incident angle], it can be applied. For example, since what forms detailed irregularity on a glass substrate, gives the diffusion property of light, uses for the filter of a taking lens etc., and acquires the soft focus effectiveness changes a diffusion property according to the incident angle of light, if it is going to acquire fixed effectiveness, its application of this invention is effective.

[0047]

[Effect of the Invention] Since the opening core of a diaphragm of a light filter is formed in the shape of [which is mostly made into center of curvature] a curved surface according to this invention as explained above, even if optical system is not constituted as telecentric system, whenever [incident angle / of the beam of light to a light filter] cannot be depended on image quantity, but can be made almost the same. Therefore, a dependency can be reduced whenever [incident angle / of the light filter of an interference pattern], and good photography image quality can be acquired.

[0048] Moreover, since the light filter is formed in the above-mentioned configuration and emission or astriction will be received in case the beam of light which reached the image surface reflects in a light filter side on front faces, such as a solid state image sensor arranged in the image surface, and reflects with a light filter further, in case this reflected beam of light carries out incidence to an image sensor again, the flux of light has spread, and effect on the image pick-up engine performance can be lessened.

[0049] If it constitutes so that the above-mentioned formula (1) may be satisfied when the radius of curvature of a light filter is set to r and the direction

distance of an optical axis of a diaphragm and a light filter is especially set to L, change of the filter shape by whenever [incident angle] is lessened, and it can prevent that the image from which image quality and the quantity of light differ by image quantity is formed. Moreover, effect of the ghost by the reflected light in a light filter can be lessened.

[0050] In addition, if a light filter is formed on the front face of lenses (image formation lens etc.) required for optical system originally, the light filter member which the former became independent of is made unnecessary, and the above-mentioned effectiveness can be acquired, preventing the increment in the number of components.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] The block diagram of the photography optical system which is the 1st operation gestalt of this invention.

[Drawing 2] Drawing showing the locus of the beam of light in the above-mentioned photography optical system.

[Drawing 3] Drawing showing the locus of the beam of light in the above-mentioned photography optical system.

[Drawing 4] The block diagram of the photography optical system which is the 2nd operation gestalt of this invention.

[Drawing 5] Drawing showing the locus of the beam of light in the photography optical system of the above-mentioned 2nd operation gestalt.

[Drawing 6] Drawing showing the locus of the beam of light in the photography optical system of the above-mentioned 2nd operation gestalt.

[Description of Notations]

1 20 Image formation lens

2 Drawing

3 Image Formation Side (Installation Side of Individual Image Sensor)

13 23 Infrared cut-off filter

[Translation done.]

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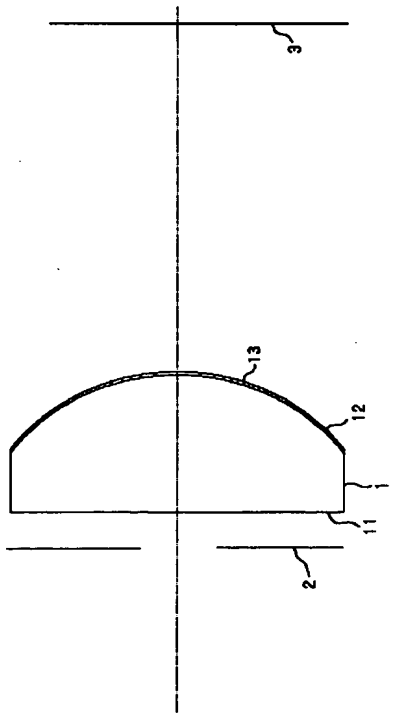
(54)【発明の名称】　撮影光学系および撮影装置

(57)【要約】
【課題】　テレセントリック系でない場合に、固体撮像素子の直前に光学フィルタを設けると、像高による感度分布にむらが生じてしまう。
【解決手段】　撮影光学系は、絞り２と、この絞りの開口中心をほぼ曲率中心とする曲面状に形成された干渉型の光学フィルタ（例えば、赤外カットフィルタ）１３とを有する。光学フィルタは、レンズ１の表面に形成してもよい。



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【特許請求の範囲】

【請求項１】　絞りと、この絞りの開口中心をほぼ曲率中心とする曲面状に形成された光学フィルタとを有することを特徴とする撮影光学系。

【請求項２】　前記光学フィルタが干渉型フィルタであることを特徴とする請求項１に記載の撮影光学系。

【請求項３】　前記光学フィルタが、前記絞りよりも像面側に配置され、像面側に凸となる曲面形状を有することを特徴とする請求項１又は２に記載の撮影光学系。

【請求項４】　前記光学フィルタが、前記絞りよりも物体側に配置され、物体側に凸となる曲面形状を有することを特徴とする請求項１又は２に記載の撮影光学系。

【請求項５】　前記光学フィルタが、レンズの表面上に形成されていることを特徴とする請求項１から４のいずれかに記載の撮影光学系。

【請求項６】　前記光学フィルタが、レンズの表面上に蒸着形成されていることを特徴とする請求項５に記載の撮影光学系。

【請求項７】　前記光学フィルタを通過した光束により形成される像を撮像する固体撮像素子を有することを特徴とする請求項１から６のいずれかに記載の撮影光学系。

【請求項８】　前記光学フィルタが、赤外カットフィルタであることを特徴とする請求項１から７のいずれかに記載の撮影光学系。

【請求項９】　前記光学フィルタの曲率半径をｒとし、前記絞りと前記光学フィルタとの光軸方向距離をＬとしたときに、

０．７＜ｒ／Ｌ＜１．５

を満足することを特徴とする請求項１から８のいずれかに記載の撮影光学系。

【請求項１０】　請求項１から９のいずれかに記載の撮影光学系を備えたことを特徴とする撮影装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、デジタルスチルカメラやビデオカメラ等の撮影装置に用いられる撮影光学系に関するものであり、特に固体撮像素子の感度特性を補正するための光学フィルタを備えた撮影光学系に関するものである。

【０００２】

【従来の技術】撮像装置における画像取り込み手段として固体撮像素子を用いる場合、固体撮像素子の特性上、分光感度特性を補正するための光学フィルタを撮影光学系内に設けることが多い。

【０００３】例えば、赤外成分をカットするために、固体撮像素子の直前に誘電体多層膜をガラス基板に蒸着した干渉型の赤外カットフィルタ部材を配置する。

【０００４】ところで、薄膜による光の干渉を利用する干渉型フィルタの場合、光線の入射角によりその特性が

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変化する。例えば、干渉型の赤外カットフィルタの場合、通常は人間の視感度に固体撮像素子の感度を一致させるために、波長７００ｎｍ程度以上の光を反射するような設定になっているが、これは設定された光の入射角に対するもので、入射角が異なると反射する波長が異なってくる。

【０００５】そして一般の撮影レンズの構成では、被写体像高により固体撮像素子への入射角が異なる。したがって、このような場合、光学フィルタの特性が異なってしまう。

【０００６】これを避けるために、従来は、レンズ射出瞳が無限遠になるように、絞りよりも像面側のレンズ焦点位置に絞りを配置する、いわゆるテレセントリック系を構成し、撮像素子の直前に設けられたフィルタに全像高への光束が垂直に入射するように設定されている。

【０００７】

【発明が解決しようとする課題】しかしながら、撮影装置のコンパクト化の要求に伴い、撮像レンズの小型化が進むと、このようなテレセントリック系を構成することができなくなってくる。したがって、従来のように固体撮像素子の直前に光学フィルタを設けたのでは像高による感度分布にむらが生じてしまう。

【０００８】また、複数のレンズから構成される撮像レンズの一部に干渉型の光学フィルタを形成した場合、フィルタ部で反射した光束が他のレンズの周辺部やレンズ鏡筒端部で反射して複雑な光路をとり、遮光しきれないゴーストになったり、固体撮像素子の表面の反射光が光学フィルタで反射し再び固体撮像素子に入射するゴースト光となったりするという問題がある。

【０００９】そこで、本発明は、単純な構成で、固体撮像素子の感度特性等を補正することができ、良好な画質を得ることができる撮影光学系を提供することを目的としている。

【００１０】

【課題を解決するための手段】上記の目的を達成するために、本発明の撮影光学系は、絞りと、この絞りの開口中心をほぼ曲率中心とする（つまりは絞り開口の中心に対してほぼコンントリックな）曲面状に形成された光学フィルタ（例えば、干渉型の赤外カットフィルタ）とを有する。

【００１１】具体的には、例えば、光学フィルタが絞りよりも像面側に配置されている場合に、光学フィルタを像面側に凸となる曲面形状に形成したり、光学フィルタが絞りよりも物体側に配置されている場合に、光学フィルタを物体側に凸となる曲面形状に形成する。

【００１２】これにより、光学系がテレセントリック系として構成されていなくても、光学フィルタへの光線の入射角度を像高によらずほぼ同一とすることが可能となり、干渉型の光学フィルタの入射角度依存性を低減して、良好な撮影画質を得ることが可能となる。

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【００１３】また、像面に達した光線が像面に配置された固体撮像素子等の表面で光学フィルタ側に反射し、さらに光学フィルタで反射する際には、光学フィルタが上記形状に形成されているため、発散又は収斂作用を受けることになり、この反射光線が再び撮像素子に入射する際には光束が広がっており、撮像性能への影響は少なくなる。

【００１４】特に、光学フィルタの曲率半径をｒとし、絞りと光学フィルタとの光軸方向距離をＬとしたときに、

０．７＜ｒ／Ｌ＜１．５　…（１）

を満足するように構成することが望ましい。

【００１５】上記式（１）の範囲を逸脱すると、入射角度によるフィルタ特性が大きく変化し、像高によって画質や光量の異なる像が形成される。また、フィルタでの反射光によるゴーストの影響を受ける可能性が高くなる。

【００１６】なお、光学フィルタを、光学系に本来必要なレンズ（結像レンズ等）の表面上に形成することにより、従来の独立した光学フィルタ部材を不要とし、部品数の増加を防止しつつ上記効果を得ることが可能となる。

【００１７】

【発明の実施の形態】（第１実施形態）図１には、本発明の第１実施形態である撮影光学系の構成を示している。なお、この撮影光学系は、デジタルスチルカメラやビデオカメラ等の撮影装置に用いられるものであり、撮影装置本体に一体的に構成されたレンズ鏡筒内に収容されたり、撮影装置本体に対して着脱可能な交換レンズ内に収容されたりする。

【００１８】図１において、２は絞りであり、その中央には撮影光束を通過させるための開口が形成されている。

【００１９】１は結像レンズであり、絞り２よりも像面側に配置されている。この結像レンズ１の物体側の面は平面１１として、像面側の面は凸面１２として構成されている。３は結像面であり、ここにはＣＣＤ等の固体撮像素子が配置される。

【００２０】結像レンズ１の凸面１２上には、誘電体多層膜による赤外カットフィルタ（干渉型光学フィルタ）１３が蒸着により形成されている。この赤外カットフィルタ１３は、波長７００ｎｍ程度以上の光の大部分を反射する特性を有し、固体撮像素子の波長感度分布を視感度に合わせる働きを有する。

【００２１】そして、結像レンズ１の凸面１２の曲率中心は、絞り２の開口中心とほぼ一致するように設定されている。このため、凸面１２上に形成された赤外カットフィルタ１３の曲率中心も、絞り２の開口中心とほぼ一致する。

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	曲率	間隔	屈折率	ｒ／Ｌ
絞り（２）	∞	0.1	1（空気）	－
Ｓ１（平面１１）	∞	0.3962	1.5247	∞
Ｓ２（凸面１２）	-0.52793		1（空気）	1.06

の関係がある。

【００２２】これにより、絞り２の開口中心を通る主光線（光軸に平行に入射した光線だけでなく光軸に対して斜めに入射した光を含む）は凸面１２および赤外カットフィルタ１３にほぼ垂直に入射する。

【００２３】つまり、赤外カットフィルタ１３への光線の入射角度は、像高によらずほぼ同一となる。これにより、赤外カットフィルタ１３への入射角度差によるカット波長の違いを小さくすることができ、像高による色温度変化や光量の変化を小さくすることができる。

【００２４】図２には、絞り２、結像レンズ１および赤外カットフィルタ１３を通過して固体撮像素子に入射する可視領域の光線とわずかではあるが赤外カットフィルタ１３を通過した赤外領域の波長を含む光線の軌跡と、固体撮像素子の表面と赤外カットフィルタ１３（当然に赤外領域で高い反射率を有する）とで反射した赤外領域光線の軌跡を示している。

【００２５】固体撮像素子で反射した赤外光線は、赤外カットフィルタ１３で反射し再び撮像素子の方向に向かう。

【００２６】しかし、本実施形態では、赤外カットフィルタ１３が像面側に凸となっていることによって、赤外カットフィルタ１３で反射した赤外光線ＲＬは大きな発散作用を受け、固体撮像素子に再び入射する際には光束が広がっていることによって撮像性能への影響は軽微なものとなる。

【００２７】一方、図３には、固体撮像素子の表面と結像レンズ１の平面１１とで反射する光線の軌跡を示す。

【００２８】撮像素子表面の点３１で反射して結像レンズ１に入射した光線は、凸面１２の作用でほぼ平行光束となって平面１１で反射する。この反射光線は、再び凸面１２で集光作用を受けて撮像素子の方向に向かう。この結果、撮像素子表面の点３２には、十分に集光された光が結像し、本来の結像性能への影響が大きなゴースト光となってしまう。したがって平面１１には反射によって不要な波長成分をカットするフィルターを設置することは望ましくない。ここにはむしろ波長全域において反射率を低減する反射防止フィルターを設置すべきである。

【００２９】次に、本実施形態の数値実施例について説明する。撮影光学系の焦点距離を１としたとき、

【００３０】つまり、本実施形態では、上記式（１）で

ある、

0．7＜r／L＝1．06＜1．5

を満足しており、入射角度によるフィルタ特性の変化を少なくし、像高によって画質や光量が異なることを防止している。また、フィルタ１３での反射光によるゴーストの影響を少なくしている。

【００３１】なお、結象性能改善のため、Ｓ２（凸面１２）を非球面として形状に若干の変更を加えてもよい。

【００３２】（第２実施形態）図４には、本発明の第２実施形態である撮影光学系の構成を示している。なお、この撮影光学系は、デジタルスチルカメラやビデオカメラ等の撮影装置に用いられるものであり、撮影装置本体に一体的に構成されたレンズ鏡筒内に収容されたり、撮影装置本体に対して着脱可能な交換レンズ内に収容されたりする。

【００３３】図４において、２は絞りであり、その中央には撮影光束を通過させるための開口が形成されている。

【００３４】２０は結像レンズであり、絞り２よりも物体側に配置されている。この結像レンズ２０の物体側の面は凸面２１として、像面側の面は凹面２２として構成されている。３は結像面であり、ここにはＣＣＤ等の固体撮像素子が配置される。

【００３５】結像レンズ２０の凸面２１上には、誘電体多層膜による赤外カットフィルタ（干渉型光学フィルタ）２３が蒸着により形成されている。この赤外カットフィルタ２３は、波長７００ｎｍ程度以上の光を反射する特性を有し、固体撮像素子の波長感度分布を視感度に合わせる働きを有する。

【００３６】そして、結像レンズ２０の凸面２１の曲率中心は、絞り２の開口中心とほぼ一致するように設定されている。このため、凸面２１上に形成された赤外カットフィルタ２３の曲率中心も、絞り２の開口中心とほぼ一致する。

	曲率	間隔	屈折率	r／L
Ｓ１（凸面２１）	0.36829	0.06425	1.5247	1.44
Ｓ２（凹面２２）	1.14456	0.19202	1（空気）	5.96
絞り（２）	∞		1（空気）	－

つまり、本実施形態では、上記式（１）である、

0．7＜r／L＝1．44＜1．5

を満足しており、入射角度によるフィルタ特性の変化を少なくし、像高によって画質や光量が異なることを防止している。また、フィルタ２３での反射光によるゴーストの影響を少なくしている。

【００４４】なお、結象性能改善のため、Ｓ１（凸面２１），Ｓ２（凹面２２）を非球面として形状に若干の変更を加えてもよい。

【００４５】また、上記各実施形態では、結像レンズの表面上に干渉型赤外カットフィルタを蒸着形成した場合について説明したが、本発明では、赤外カットフィルタ

＊【００３７】これにより、絞り２の開口中心を通る主光線は凸面２１および赤外カットフィルタ２３にほぼ垂直に入射する。

【００３８】つまり、赤外カットフィルタ２３への光線の入射角度は、像高によらずほぼ同一となる。これにより、赤外カットフィルタ２３への入射角度差によるカット波長の違いを小さくすることができ、像高による色温度変化や光量の変化を小さくすることができる。

【００３９】図５には、赤外カットフィルタ２３、結像レンズ２０および絞り２を通過して固体撮像素子に入射する可視領域の光線とわずかではあるが赤外カットフィルタ２１を通過した赤外領域の波長を含む光線の軌跡と、固体撮像素子の表面と赤外カットフィルタ２１とで反射した光線の軌跡を示している。

【００４０】固体撮像素子で反射した光線は、レンズ２０の凹面２２および凸面２１を透過して赤外カットフィルタ２３で反射し再び撮像素子の方向に向かうしかし、本実施形態では、赤外カットフィルタ２３が物体側に凸となっていることによって、赤外カットフィルタ２３で反射した光線ＲＬは大きな収斂作用を受け、固体撮像素子に再び入射する際には光束が広がっていることによって撮像性能への影響は軽微なものとなる。

【００４１】一方、図６には、固体撮像素子の表面と結像レンズ２０の凹面２２とで反射する光線の軌跡を示す。

【００４２】撮像素子表面で反射した光線は、凹面２２での反射により集光作用を受けて撮像素子の方向に向かう。この結果、撮像素子表面には、十分に集光された光が結像し、本来の結像性能への影響が大きなゴースト光となってしまう。したがって凹面２２に反射によって不要な波長成分をカットするフィルターを設けることは好ましくない。

＊【００４３】次に、本実施形態の数値実施例について説明する。撮影光学系の焦点距離を１としたとき、

以外の光学フィルタを結像レンズの表面上に蒸着以外の方法で形成してもよいし、絞りの開口中心をほぼ曲率中心とする曲面形状の透明板上に光学フィルタを形成するようにしてもよい。

【００４６】また、本発明は、干渉型ではない光学フィルタであって、その特性に入射角度依存性のあるものを用いる場合にも適用することができる。たとえば微細な凹凸をガラス基板上に形成し光の拡散特性を持たせ撮影レンズのフィルターなどに利用してソフトフォーカス効果を得るものは、光の入射角により拡散特性が変わるため一定の効果を得ようとすれば本発明の適用が効果的である。

【００４７】

【発明の効果】以上説明したように、本発明によれば、光学フィルタを絞りの開口中心をほぼ曲率中心とする曲面状に形成しているため、光学系がテレセントリック系として構成されていなくても、光学フィルタへの光線の入射角度を像高によらずほぼ同一とすることができる。したがって、干渉型の光学フィルタの入射角度依存性を低減して、良好な撮影画質を得ることができる。

【００４８】また、像面に達した光線が像面に配置された固体撮像素子等の表面で光学フィルタ側に反射し、さらに光学フィルタで反射する際には、光学フィルタが上記形状に形成されているために発散又は収斂作用を受けることになるので、この反射した光線が再び撮像素子に入射する際には光束が広がっており、撮像性能への影響を少なくすることができる。

【００４９】特に、光学フィルタの曲率半径をｒとし、絞りと光学フィルタとの光軸方向距離をＬとしたときに、上記式（１）を満足するように構成すれば、入射角度によるフィルタ特性の変化を少なくし、像高によって画質や光量が異なる像が形成されることを防止できる。また、光学フィルタでの反射光によるゴーストの影響を少なくすることができる。

【００５０】なお、光学フィルタを、光学系に本来必要なレンズ（結像レンズ等）の表面上に形成するようにすれば、従来の独立した光学フィルタ部材を不要とし、部品数の増加を防止しつつ上記効果を得ることができる。

【図面の簡単な説明】

【図１】本発明の第１実施形態である撮影光学系の構成図。

【図２】上記撮影光学系における光線の軌跡を示す図。

【図３】上記撮影光学系における光線の軌跡を示す図。

【図４】本発明の第２実施形態である撮影光学系の構成図。

【図５】上記第２実施形態の撮影光学系における光線の軌跡を示す図。

【図６】上記第２実施形態の撮影光学系における光線の軌跡を示す図。

【符号の説明】

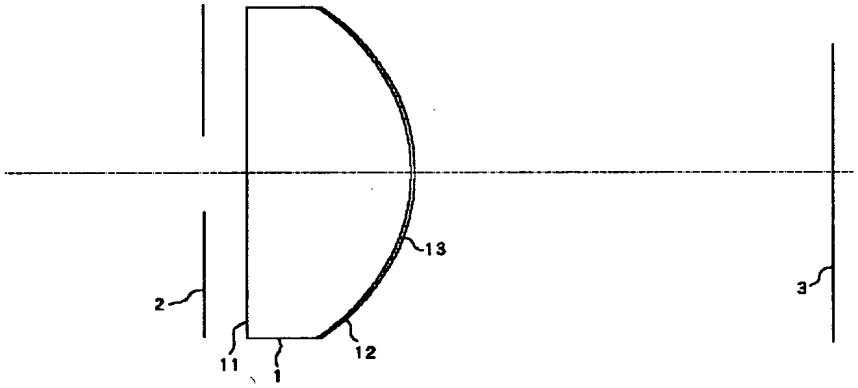
１，２０　結像レンズ

２　絞り

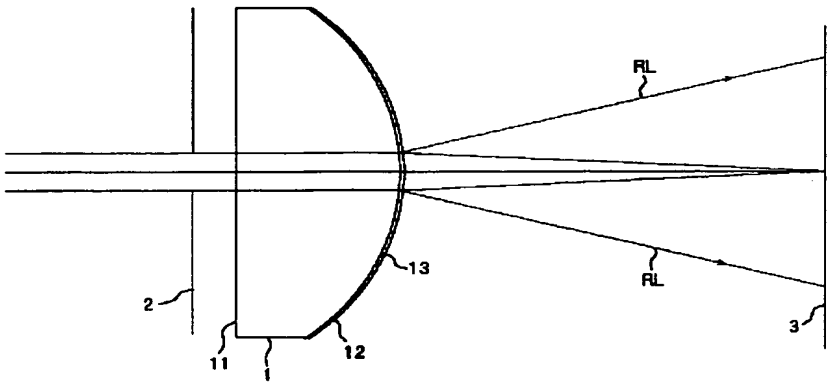
３　結像面（個体撮像素子の設置面）

１３，２３　赤外カットフィルタ

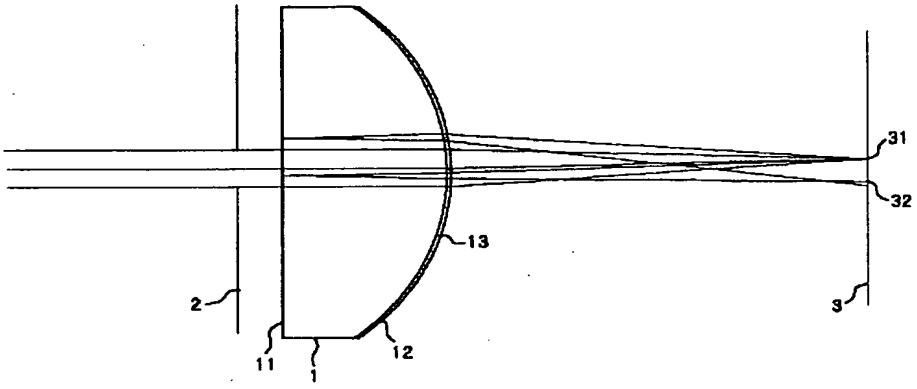
【図１】



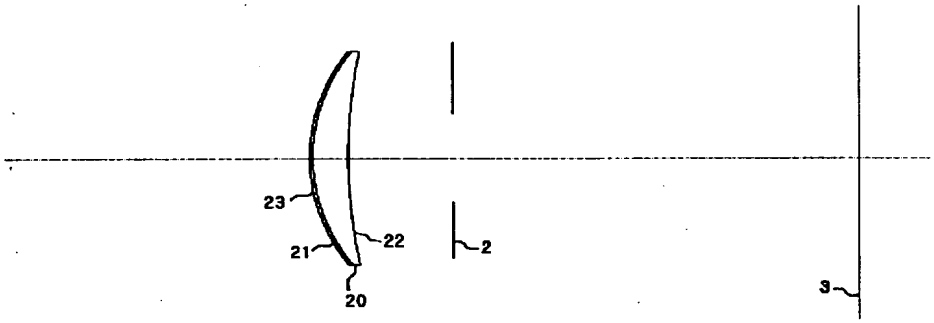
【図２】



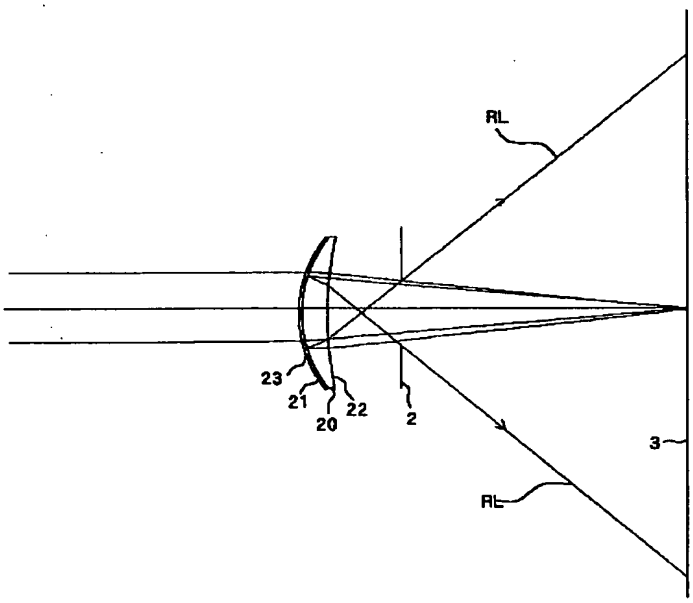
【図３】



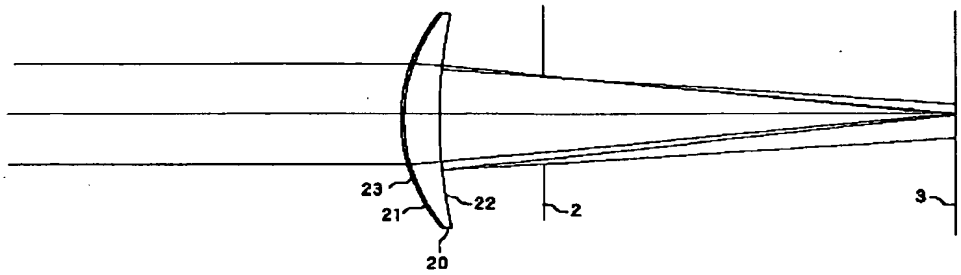
【図４】



【図５】



【図６】



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